INNOVATION ACTIVITY AND ENTERPRISES' SIZE

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Abstract

The article investigates the relationship between the size of an enterprise and innovation activity. The existing literature and the results of empirical studies are ambiguous in their findings whether large or rather small and medium enterprises shall be considered as the key bearers of innovation activity. Our analysis was performed in the conditions of eight industry sectors in Slovakia for the 2008 – 2012 period using average data on sectoral level. Our results show the existence of a positive statistically significant relationship between size and innovation activity that seems to be rather nonlinear. The article forms the partial output of the scientific project VEGA No. 1/0328/13 „Modelling of causal relations of innovations in small and medium enterprises".

Key words

Innovation activity, enterprises´ size, small and medium enterprises, industry, R&D employees

Introduction

Numerous studies on the relationship between innovation activity and firm size have been conducted to test the Schumpeterian hypothesis about the advantages of size for innovative activity. However, as noted by Fisher and Temin (1973) the most commonly used test of the Schumpeterian hypothesis, "which is to ask if the proportion of workers or expenditures in firms used in R & D activities increases with firm size …is in fact not a test of Schumpeter´s ideas on the size of firms". McNulty (1974) in his subsequent work pointed out that the innovating firm of the Schumpeterian system was not defined in terms of size so much as in terms of competitive behavior. Nevertheless, Schumpeter´s works provoked discussion about the role of size on radical innovation and plenty of authors concluded that there is a conflict that continues today (Chandy, Tellis, 2000). In principle there are standing opposite each other two basic concepts of the notions preferring either small and medium enterprises, or large enterprises as the key bearers of innovation activity.

According to Chandy and Tellis (2000), in compliance with the theory of inertia, large firms are less likely to provide the responsive, risk-taking atmosphere needed for the development of radical innovations. In other words, smaller enterprises are considered to be more innovative due to a more flexible climate for making quicker decisions to go ahead with new ambitious projects, higher ability to reflect on opportunities, less difficulty in implementing necessary changes (Dean, Brown, Bamford, 1998). Similarly Cohen and Klepper (1996) concluded that the propensity to perform R & D and the amount of R & D conducted by performers are closely related to the size of the firm, while R & D productivity declines with firm size. Their findings indicate that a large firm size is no advantage in conducting R & D. Ferencz and Dugas (2012) state that small and medium enterprises play increasingly significant roles in creating and applying innovations.

On the other hand, large firms are considered to be more innovative because of their significant financial and technical capabilities, economies of scale, ability to hire quality scientific personnel. As a result, large firms are less vulnerable to the failure of a particular development project because it would entail a smaller proportion of their resources than it would for a small firm (Chandy, Tellis, 2000). Within broader research performed on manufacturing plants in Scotland, Love and Ashcroft (1999) similarly concluded that plant size, foreign ownership and the presence of R&D are all positively associated with innovations. According to them, the importance of size lies principally in encouraging further innovations among plants which are already innovators, but less than proportionately with the increase in employment size.

While each theory has received empirical support, the findings from systematic quantitative reviews suggest a positive rather than negative relationship between size and innovation (Damanpour, 2010). A meta-analytical review of 36 correlations from 20 empirical studies found a mean correlation of 0,32 ($p<0,05$) between size and innovation (Damanpour, 1992). A more recent and larger meta-analysis of 87 correlations from 53 studies found a smaller yet statistically significant mean correlation between size and innovation (Camison-Zornoza, Lapiedra-Alcami, Segarra-Cipres, Boronat-Navarro, 2004). Plenty of authors further examined the relative effect of size on product and process innovations separately and it can be concluded that size has a more positive association with process than with product innovations (Fritsch, Meschede, 2001).

Emerging from the above, the aim of the article is to reexamine the relation between the size of an enterprise and innovation activity on a sample of chosen manufacturing industries within the Slovak Republic.

Materials and Methods

Our analysis was conducted over the 2008–2012 period under the conditions of the following manufacturing industries within the Slovak Republic classified according to the two-digit industry level SK NACE Rev. 2. classification: manufacture of food products and beverages (code 10 and 11), manufacture of chemicals and chemical products (code 20), manufacture of rubber and plastics products (code 22), manufacture of other non-metallic mineral products (code 23), manufacture of fabricated metal products, except machinery and equipment (code 25), manufacture of computer, electronic and optical products (code 26), manufacture of machinery and equipment n.e.c. (code 28), manufacture of motor vehicles, trailers and semi-trailers (code 29).

Innovation activity can be measured through input indicators (e. g. R&D expenditures, number of R&D employees, etc.) and/ or output indicators (e. g. number of patents, licenses, amount of intangible assets, etc.) (Zemplinerová, 2010). Each of the variables has its disadvantages (see for example Grilliches, 1986) and in empirical works more variables to express innovation activity are usually used. For the purpose of our analysis we used input indicators as measures of innovation activity, i.e., the . average number of R&D employees in head counts (R&D_E_A) and in man years (R&D_E*_A) and average gross domestic expenditures on R&D (GERD_A).

R&D employees are persons directly engaged in R&D as well as employees rendering direct services to R&D who carried out R&D activity or direct service in the scope of at least 200 hours during the year. R&D employees are reported, except for physical persons, in head counts as of 31 December as well as according to the FTE (FTE – Full Time Equivalent) in

man-years. FTE per employee is calculated as a ratio of the sum of hours worked being devoted to R&D activity during the year under observation and the value 2000, where 2000 means the working capacity of the employee during the year.

R&D expenditures include total expenditures on R&D activities within an organization, i.e., domestic expenditures. They include capital and current expenditures. From expenditures being spent outside the organization only those are included which serve as a support to the internal research and development (e.g. purchase of equipment for R&D). The depreciation of buildings, machinery equipment and equipment is excluded.

The size of enterprise was measured based on the average number of employees (E_A) and average turnover from its own products and services (T_A). We worked also with an additional variable, namely the number of firms operating within a particular industry (F) because it is another important variable indicating the nature of industry structure and subsequently competitive behavior.

The input data on innovation activity as well as on terminology used to refer to the variables were taken from Yearbooks of Science and Technology published by the Statistical Office of Slovak Republic. The input data on enterprise size and number of firms operating within the investigated industries were drawn from the Industry Yearbooks published by the Statistical Office of the Slovak Republic.

The analysis of the relationship between innovation activity and an enterprise's size was performed through correlation analysis using Pearson and Spearman correlation coefficients as well as through regression analysis. Three models were constructed to evaluate the combined effect of explanatory variables (firm size and number of firms) on innovation activity.

Results and Discussion

Table 1 shows the descriptive characteristics of the studied variables. Although the share of average gross domestic expenditures on R&D on turnover from their own products and services is only 0.15 %, the share of the average number of R&D employees compared to the average number of employees reached nearly 1 %. As the proportion of innovation activity expressed through various indicators is different, it is reasonable to use more variables as measures of innovation activity.

Variable	Mean	Std Dev	Median	Min	Max
E_A	197.894	122.761	154.186	74.705	534.974
T_A	41382.211	44670.483	16161.531	5744.385	175633.215
F	164.450	99.785	137.000	48.000	386.000
R&D_E_A	1.396	1.054	0.902	0.086	3.291
R&D_E*_A	1.008	0.765	0.721	0.082	2.453
GERD_A	62.318	90.695	37.157	3.412	405.860

Tab. 1: Descriptive characteristic of studied variables

	R&D_E_A		R&D_E*_A		GERD_A		R&D_E_A		R&D_E*_A		GERD_A	
	Pearson correlation coefficient						Spearman correlation coefficient					
E_A	0.4936	***	0.4797	***	0.7951	***	0.7394	***	0.7178	***	0.7310	***
T_A	0.4951	***	0.5033	***	0.7330	***	0.6223	***	0.6178	***	0.6372	***
F	-0.5478	***	-0.5551	***	-0.2831	*	-0.5601	***	-0.5639	***	-0.4322	***

Notes: Pearson correlation coefficients, ***, **, * denote significance at 1. 5 and 10 % levels, respectively

Tab. 2: Pearson and Spearman correlation coefficients

The following table 2 shows the results of the correlation analysis. A statistically significant positive relationship is detected between indicators of innovation activity and the size of the firm in every examined case. On the other hand, a statistically significant negative correlation is detected between the number of firms within an industry and innovation activity. This finding supports the previous one, due to the fact that a decreasing number of firms (in connection with possible growth of their size) supports innovation activity. In the case of the relation between the average number of R&D employees and variables representing the size of the firm, significantly higher values of Spearman correlation coefficients are detected that can indicate the existence of rather nonlinear relations between studied variables.

The relations where the biggest differences between the Pearson and Spearman correlation coefficients were detected were analyzed more thoroughly using a graphic display. In both cases the relations are better explained by nonlinear trends. It indicates that with the growth of firm size, the innovation activity measured by the average number of R&D employees' increases, though only to a certain point and then starts to stagnate or decline.

These findings indicate some similarities with the results of the empirical research by Scherer (1965), who found that inventive output increases with the size of a firm, but generally at a less than proportional rate and the indicated existence of a nonlinear relation between size and innovation. Subsequently Kamien and Schwartz (1975) within their review of empirical works state that innovation activity probably increases with the size of a firm, though only up to certain point and then it stabilizes or decreases. Similar findings are presented also in the work of Zemplinerová (2010). These findings indicate the existence of an inverted U curve relationship between a firm's size and innovation activity. Other empirical studies showed a rather nonlinear relationship in the sense that small and large firms are more innovative than firms of intermediate size (Bertschek, Entorf, 1996).

We further studied the combined effect of firms' size and the number of firms within an industry on innovation activity through linear regression analysis. We tested 3 models in which dependent variable indicators of innovation activity were used respectively and all studied variables were used as explanatory variables. The models as a whole are statistically significant, however, not all variables in the studied regression models are significant. The highest significance shows the last model, which can explain 64.74 % variability of the dependent variable. However, only a firm size measured by the number of employees is statistically significant in this model. The increase in the number of employees has a positive effect on innovation activity measured by average gross domestic expenditures on R&D. In the rest of the models

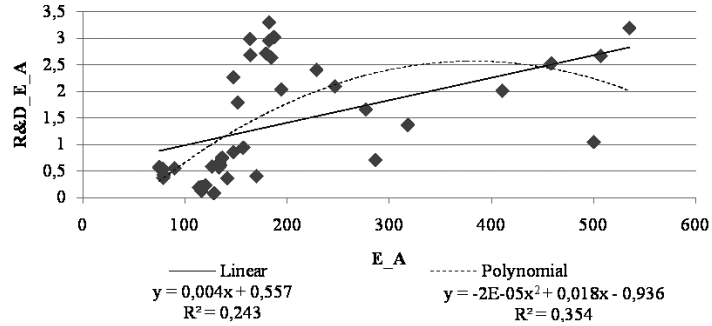

Fig. 1: Relation between the average number of R&D employees and the average number of employees

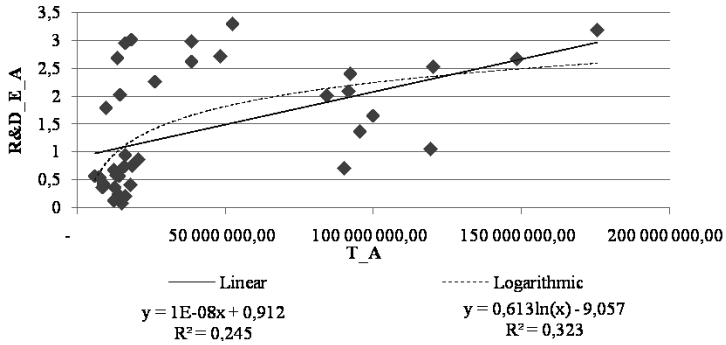

Fig. 2: Relation between the average number of R&D employees and average turnover

the number of firms operating within the industry is a statistically significant variable and its increase indicates a negative effect on innovation activity measured by the average number of R&D employees. The results of the regression analysis in principle confirmed the findings resulting from correlation analysis.

	Parameter estimate	Standard Error	T Value	Pr > |t|	R-Square
Model 1: Dependent Variable R&D_E_A					
Intercept	0.449	0.366	1.23	0.2275	-
E_A	0.008	0.004	1.95	0.0584	-
T_A	1.309E-8	9.257E-9	1.41	0.1658	-
F	-2.374E-10	9.061E-11	-2.62	0.0128	-
				0.0007	0.3721
Model 2: Dependent Variable R&D_E*_A					
Intercept	1.275	0.360	3.54	0.0011	-
E_A	0.0003	0.002	0.15	0.8839	-
T_A	4.156E-9	6.585E-9	0.63	0.5320	-
F	-0.003	0.002	-2.60	0.0135	-
				0.0007	0.3716
Model 3: Dependent Variable GERD_A					
Intercept	-86.065	31.978	-2.69	0.0107	-
E_A	0.656	0.209	3.15	0.0033	-
T_A	-9.366E-8	5.845E-7	-0.09	0.9274	-
F	0.126	0.105	1.20	0.2383	-
				<.0001	0.6474

Tab. 3: Results of linear regression analysis

Conclusion

Our findings indicate the existence of a positive statistically significant relationship between the size of a firm and innovation activity that seems to be rather nonlinear. The nonlinearity can be explained by contradictory tendencies in the form of the advantage of large enterprises by generating resources necessary for innovations on the one hand, and the advantage of small and medium enterprises in flexibility and motivation to innovations on the other. It can be assumed that firm size does matter for innovation activity. Although the results of this study find more of a positive relationship between size and innovation activity, it is not sufficient to conclude that big firms are better innovators than smaller firms. The nature of this relationship and its limits can also be analyzed more thoroughly with regards to differences in competitive behavior.

References

Bertschek, I., Entorf, H. 1996. On nonparametric estimation of the Schumpeterian link between innovation and firm size: Evidence from Belgium, France, and Germany. In: *Empirical Economics,* vol. 21, 1996, No. 3, p. 401-426.

Camison-Zornoza, C., Lapiedra-Alcami, R., Segarra-Cipres, M., Boronat-Navarro, M. 2004. A meta-analysis of innovation and organizational size. In: *Organization Studies*, vol. 25, 2004, No. 3, p. 331–361.

Cohen, W. M., Klepper, S. 1996. A reprise of size and R&D. In: *The Economic Journal*, vol. 106, 1996, No. 437, p. 925–951.

Damanpour, F. 1992. Organizational size and innovation. In: *Organization Studies*, vol. 13, 1992, No. 3, p. 375–402.

Damanpour, F. 2010. An integration of research findings of effects of firm size and market competition on product and process innovations. I n: *British Journal of Management*, vol. 21, 2010, No. 4, p. 996–1010.

Dean, T. J., Brown, R. L., Bamford, C. E. 1998. Differences in large and small firm responses to environmental context: strategic implications from a comparative analysis of business formations. In: *Strategic Management Journal*, vol. 19, 1998, No. 8, p. 709–728.

Ferencz, V., Dugas, J. 2012. *Management of Innovation*. Brussels : EuroScientia, 2012.

Fischer, F. M., Temin, P. 1973. Returns to scale in research and development: What does the Schumpeterian hypothesis imply? In: *Journal of Political Economy,* vol. 81, 1973, No. 1, p. 56–70.

Fritsch, M., Meschede, M. 2001. Product innovation, process innovation, and size. In: *Review of Industrial Organization*, vol. 19, 2001, No. 3, p. 335–350.

Grilliches, Z. 1986. Productivity, R&D, and basic research at the firm level in the 1970´s. In: *American Economic Review,* vol. 76, 1986, No. 1, p. 141–154.

Chandy, R. K., Tellis, G. J. 2000. The incumbent´s curse? Incumbency, size and radical product innovation. In: *Journal of Marketing*, vol. 64, 2000, No. 3, p. 1–17.

Kamien, M. I., Schwartz, N. L. 1975. Market structure and innovation: a survey. In: *Journal of Economic Literature*, vol. 13, 1975, No. 1, p. 1–37.

Love, J. H., Ashcroft, B. 1999. Market versus corporate structure in plant-level innovation performance. In: *Small Business Economics*, vol. 13, 1999, No. 2, p. 97–109.

McNulty, P. J. 1974. On firm size and innovation in the Schumpeterian system. In: *Journal of Economic Issues,* vol. 8, 1974, No. 3, p. 627–632.

Scherer, F. M. 1965. Firm size, market structure, opportunity, and the output of patented inventions. In: *The American Economic Review*, vol. 55, 1965, No. 5, p. 1097–1125.

Zemplinerová, A. 2010. Inovační aktivita firem a konkurence. In: *Politická ekonomie*, vol. 58, 2010, No. 6, p. 747–760.

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